UNCLASSIFIED

AD NUMBER
AD889752
LIMITATION CHANGES
TO: **Approved for public release; distribution is unlimited.**
FROM: **Distribution: Further dissemination only as directed by Aeronautical Systems Division, Attn: SDQH, Wright-Patterson AFB, OH 45433, MAR 1971, or higher DoD authority. This document contains export-controlled technical data.**
AUTHORITY
ASD ltr, 17 Apr 1974

THIS PAGE IS UNCLASSIFIED

FTC-TR-71-9

AD INEXPLORATA

AFFTC

UH-1N INSTRUMENT FLIGHT, TURBULENCE, AND ICING TESTS

DONALD J. DOWDEN
Icing Project Engineer

THEODORE E. ANGLE
Major, USAF
Project Pilot

TECHNICAL REPORT No. 71-9

MARCH 1971

This document may be further distributed by any holder only with specific prior approval of ASD (SDQH), Wright-Patterson AFB, Ohio 45433.

AIR FORCE FLIGHT TEST CENTER
EDWARDS AIR FORCE BASE, CALIFORNIA
AIR FORCE SYSTEMS COMMAND
UNITED STATES AIR FORCE

FTC-TR-71-9

UH-1N INSTRUMENT FLIGHT, TURBULENCE, AND ICING TESTS

DONALD J. DOWDEN
Icing Project Engineer

THEODORE E. ANGLE
Major, USAF
Project Pilot

FOREWORD

This report, one of a series of UH-1N reports, presents the results of the Adverse Weather Test Program on a UH-1N helicopter, USAF serial number 68-10774, at Edwards Air Force Base, California; Howard Air Force Base, Panama, and Malmstrom Air Force Base, Montana. These tests were conducted between 19 October 70 and 7 February 71 under the authority of the AFFTC Project Directive 69-49A.

The cooperation of the United States Air Force Southern Command and assistance of the 24th Special Operations Wing in support of the Instrument Flight Test Evaluation/Tropical Weather Tests are greatly appreciated.

The Strategic Air Command, 341st Wing, Malmstrom AFB, is also commended for the base support and assistance provided in the conduct of the icing test program. Other pilots who assisted with conduct of the instrument flight evaluation and icing test program were Air Force Majors Sidney E. Gurley and Paul J. Balfe. The authors of this report also wish to express their appreciation to the UH-1N project officer, Mr. Jo' , R. Somsel, for his contributions to the efficient conduct of this program and for his technical assistance in the preparation of this report.

Foreign announcement and dissemination by the Defense Documentation Center are not authorized because of technology restrictions of the U.S. Export Control Acts as implemented by AFR 400-10.

Prepared by:

DONALD J. DOWDEN
Icing Project Engineer

THEODORE E. ANGLE
Major, USAF
Project Pilot

Reviewed and approved by:
16 MARCH 1971

THOMAS J. CECIL
Colonel, USAF
Commander, 6510 Test Wing

ROBERT M. WHITE
Brigadier General, USAF
Commander

ABSTRACT

Operational techniques and procedures were established for the UH-1N flight in IFR weather flight conditions and were recommended for inclusion in Section IX of the Flight Manual T.O. 1H-1(U)N-1. Safe flight in IFR weather is possible, but two pilots were recommended as minimum crew due to the pilot workload. The UH-1N was flown in icing conditions with no mechanical defects or gross degradation of handling qualities noted. The windshield defrost system was inadequate to keep the windshield clear of ice and ice accumulated in the engine inlet duct throughout most of the icing tests conducted. Therefore, the UH-1N should be restricted from flight in icing conditions greater than clear trace; that is, in areas of icing conditions where the outside air temperature is colder than -5 degrees C.

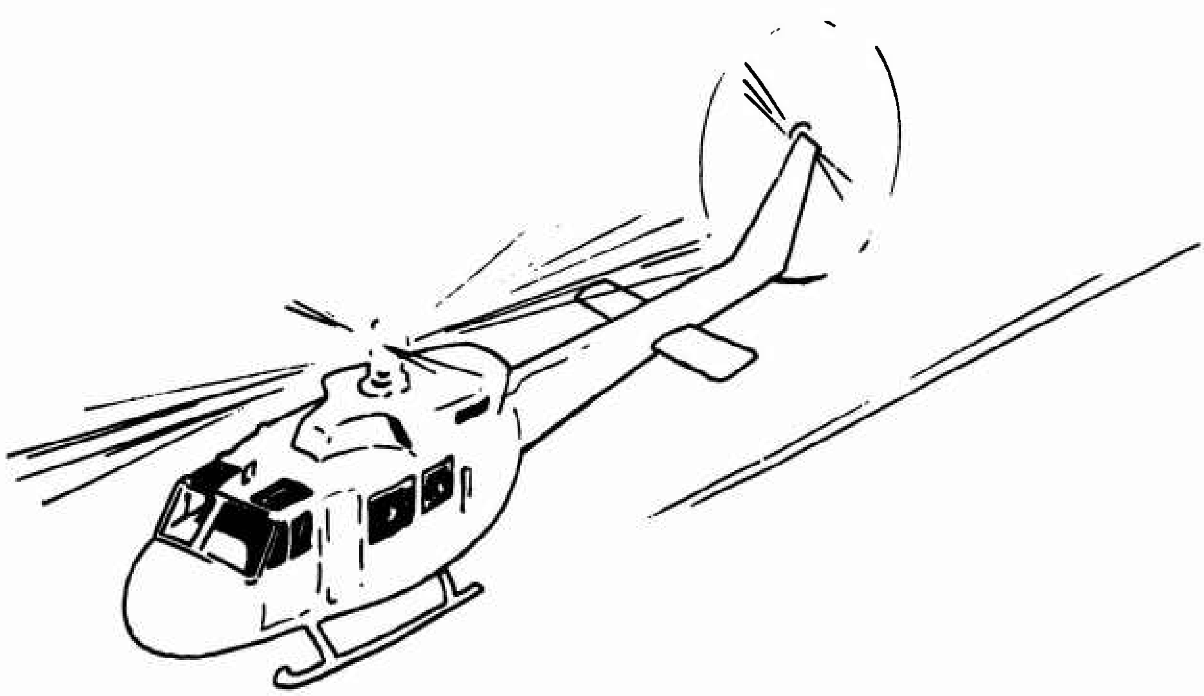
table of contents

list of illustrations

list of tables

list of abbreviations

Item	Definition
BHC	Bell Helicopter Company
EAPS	engine air particle separator
GCA	ground controlled approach
KIAS	knots indicated airspeed
OAT	outside air temperature (degrees C)
RUMR	routine maintenance unsatisfactory report
tacan	tactical air navigation



INTRODUCTION

Flight tests of the UH-1N helicopter were conducted at Howard AFB, Panama Canal Zone, Edwards AFB, California, and Malmstrom AFB, Montana, for the purpose of:

1. Evaluating pilot instrument flight procedures and techniques described in Section IX of the Flight Manual (reference 1).

2. Evaluating the helicopter and its flight characteristics during operations in adverse weather.

3. Determining the capabilities of the UH-1N ice protection systems and overall aircraft adequacy in an icing environment.

The entire test program was conducted in UH-1N Air Force serial number 68-10774.

A total of 23.2 productive flight test hours was accumulated during the IFR procedures evaluation. These tests were begun at Howard AFB in conjunction with the UH-1N tropical weather testing (reference 2) on 23 October 1970 and finished at Edwards AFB on 12 January 1971. Flight hours are shown in table I.

A total of 8.0 productive test hours were flown during the UH-1N icing flight tests conducted at Malmstrom AFB, between 1 and 7 February 1971. Flight hours are given in table II.

Table I

SUMMARY OF INSTRUMENT FLIGHT

EVALUATION TEST TIME (hours)

	VFR	Hooded	IFR	Total
Day	5.1	9.8	6.3	21.2
Night	2.0	-	-	2.0
Total	7.1	9.8	6.3	23.2

Table II

SUMMARY OF ICING TEST TIME (hours)

Artificial	Natural	Total
8.0	2.3	10.3

DESCRIPTION OF HELICOPTER

The UH-1N test helicopter had a single, two-bladed lifting rotor and a tractor tail rotor instead of the more conventional pusher tail rotor. Both main and tail rotor blades were thin-tipped. The UH-1N used the basic UH-1D fuselage and incorporated a T400-CP-400 power package manufactured by United Aircraft of Canada Limited. The T400-CP-400 power package consisted of two PT6T-4 free-turbine turboshaft engines coupled to a combining gearbox with a single output shaft. Each engine had an uninstalled rating of 900 shaft horsepower at sea level, standard day conditions. Overrunning clutches in the two drives of the output sections allowed engine torque to be transmitted in one direction only, thus providing for both single-engine operation and two-engine-out autorotation. Load sharing between the two engines was equalized by an automatic torque-matching device. The maximum allowable forward speed of the helicopter was 130 KIAS, and the maximum gross weight was 10,000 pounds (10,500 pounds with external sling load).

TEST AND EVALUATION

■ INSTRUMENT FLIGHT PROCEDURES

● General

It was the objective of the UH-1N instrument flight test program to qualitatively evaluate:

1. Instrument takeoff, climb, and cruise.
2. Instrument descent, approaches, and missed approaches.
3. Helicopter operational effectiveness and handling qualities in rain.
4. Helicopter handling qualities in turbulent air.
5. Flight techniques for helicopter night operations.

All IFR procedures were evaluated under VFR conditions prior to hooded flight or flight through actual IFR weather conditions. The techniques ultimately chosen were based on such factors as aircraft vibration levels, pilot comfort, ease of operation (workload), and best aircraft performance. All phases of the program were flown from the pilot's as well as from the copilot's position. Forward, mid-range, and aft cg loading plus maximum gross weight to light gross weight configurations were employed to cover all aspects of possible aircraft attitude and handling qualities. Standard production line flight instruments were used during these tests.

● Pitot-Static System Check

A pitot-static system leak check using an MB-1 tester was conducted before the airspeed calibration flight. Initial checks at a tester altitude of 5,000 feet revealed leaks resulting in an airspeed error of 5 knots and altimeter bleed rate of 350 feet per minute. All pitot-static manifold fittings (reference 3, figure 92) had been installed without sealant. After sealant was applied to these fittings, an acceptable zero airspeed error and 50 feet per minute altimeter bleed rate were noted. This was considered a quality control deficiency and was reported to Bell Helicopter Company via a BHC Maintenance Deficiency Report and to the USAF in RUMR AFFTC R 70-924. In addition, T.O. 1H-1(U)N-2-1 (reference 4) did not give an adequate description of pitot-static system checks. There was no acceptable altimeter bleed rate given and no specific altitude to which to run the tester. Paragraphs 9-33/34 of T.O. 1H-1(U)N-2-1 (reference 4) should be expanded to more clearly define the conduct of a pitot-static system leak check. (R 1)[1]

After having completed the pitot-static system ground checks, a level flight airspeed calibration using a measured ground course was conducted. Test airspeeds ranged between 30 and 115 knots. Post flight computations revealed position errors of approximately 6 knots at the lower airspeeds to less than 2 knots at airspeeds between 65 and 115 knots. Indicated airspeeds below 35 knots were considered unreliable because of the relatively unstable airflow pattern brought about by translational lift, and the associated increase in helicopter vibration level and subsequent oscillation of the airspeed indicator at these lower speeds.

● Instrument Takeoff

Several instrument takeoff techniques were evaluated relative to initial attitude indicator setting, power application, and transition into forward flight. It was determined that the Flight Manual method was the simplest from a pilot workload and safety standpoint. This procedure called for setting the attitude indicator one bar width above the artificial horizon, and then, as takeoff power was obtained and the helicopter became airborne, changing the helicopter pitch attitude to a 5-degree nose low indication. When forward flight was begun from a hover, this procedure was similar to a normal takeoff with perhaps a slightly steeper flightpath angle. When takeoff was made from the ground (with no hover), there was a danger that initial helicopter yawing tendencies might not be recognized and corrected early enough to prevent over-controlling and disorientation. Also, if the latter technique was used, the initial flightpath angle had to be made steeper to assure positive ground clearance; remembering that the pitot-static instruments did not give accurate information until a forward airspeed of greater than 30 KIAS was attained.

When possible, takeoff into actual weather conditions should be made from a hover, and transition to forward flight made using outside references, that is, a normal takeoff and gradual transition from outside cues to helicopter flight instruments as airspeed and altitude increase and inflight visibility decreases.

● Instrument Climb

Determination of a best instrument climb airspeed and vertical velocity combination centered about (a) aircraft performance, (b) longitudinal speed stability, (c) ease of acquiring the desired airspeed

[1]Numbers indicated as (R 1), etc., represent the corresponding recommendation numbers as tabulated in the Conclusions and Recommendations section of this report.

following an instrument takeoff, and (d) pilot workload to maintain this combination during straight and maneuvering flight. The final technique chosen differed slightly from the Flight Manual procedure.

An airspeed of 80 KIAS and a vertical velocity of 500 to 1,000 feet per minute should be maintained during instrument climb. This combination best met the criteria stated above and should be established as soon as possible after takeoff and held until level-off procedures are initiated. Enroute changes in altitude could also be made employing this technique or at an airspeed closer to cruise conditions. Airspeeds of less than 80 KIAS and vertical velocities greater than +1,000 feet per minute are not recommended, as helicopter longitudinal instability and pilot workload increase appreciably beyond these conditions.

Maneuvering at best climb airspeed was also investigated. It was determined that although reasonable aircraft control could be maintained with bank angles of up to 30 degrees, every effort should be made to restrict turns to standard rate or approximately 18 degrees of bank.

● Instrument Cruising Flight

Cruise airspeeds of 70 to 120 KIAS were evaluated for level flight in IFR conditions. It was determined that no one airspeed should be considered as the "best" cruise airspeed to fly since several basic variables (such as gross weight, altitude, and turbulence) measurably change the qualitative handling characteristics and overall evaluation. Ultimately, it was determined that a speed range of 80 to 100 KIAS could be satisfactorily used. Eighty KIAS was good for turbulent air penetration, but too slow for normal cruise under calm air conditions. Although aircraft vibration levels generally increased at the higher airspeeds, they were tolerable at all gross weight and altitude conditions.

Maneuvering flight was also conducted at all of the above airspeeds. Although level flight could be maintained at bank angles of up to 45 degrees, the pilot workload increased considerably as the angle of bank was increased past 30 degrees. IFR flight should be conducted with standard or 1/2 standard rate turns and at bank angles not greater than 30 degrees.

● Normal Descents

Power-on descents were conducted at airspeeds ranging from 70 to 120 KIAS. It was evident, as with cruise airspeeds, that "best" descent airspeeds varied with gross weight, altitude, and turbulence. Descent at "best" cruise airspeed for each test configuration was then evaluated.

The cruise airspeed and a level cruise attitude indicator presentation should be maintained in the descent. The rate of descent should be maintained between -500 to -1,000 feet per minute, and turns performed with bank angles of less than 30 degrees.

● Autorotative Descents

In view of the relatively high descent rates incurred during autorotations and increased pilot workload to maintain complete aircraft control, autorotative descents are not recommended as a normal IFR procedure.

Autorotations within actual weather conditions may, however, be required if both engines should flame out. A study was made to develop the best technique for this eventuality.

The Flight Manual technique of holding a one-bar-width nose high attitude on the attitude indicator was evaluated first. This method brought about a stabilized airspeed of between 52 and 58 KIAS. These airspeeds were considered too low for subsequent VFR maneuvering and landing.

The next technique involved holding a level cruise presentation on the attitude indicator following simulated engine failure. Table III shows the resultant stabilized airspeeds.

The two higher cruise airspeed points resulted in an airspeed too high for stabilized autorotations. However, these airspeeds were built up slowly.

A combination of these two techniques was then employed. Following a simulated complete power loss and entry into autorotation, a level cruise presentation was regained/maintained on the attitude indicator. As the airspeed tended to change, a one-bar-width adjustment was momentarily held until the airspeed change rate was reversed; that is, level cruise presentation ± one bar width was maintained in the descent. This technique resulted in a realistic workload, good airspeed control, and a reasonable rate of descent. Airspeeds of 70-90 KIAS are recommended for autorotative descents.

Table III

STABILIZED AIRSPEEDS WITH ONE ENGINE

Beginning Cruise Airspeed (KIAS)	Stabilized Autorotation Airspeed (KIAS)
80	75
90	105
100	115

● Holding

Airspeeds of 50 to 100 KIAS were evaluated for use within an instrument approach holding pattern. The primary consideration in choosing a "best" airspeed was stability of the helicopter and ease of maintaining a constant airspeed in view of the frequent maneuvering required. Ninety KIAS was found to be the most agreeable airspeed to use. Standard rate turns should be used while in the holding pattern.

● Instrument Approaches

The evaluation criteria for instrument approach procedures were identical to those used to determine a best holding pattern airspeed. Tacan, VOR, and GCA approaches were executed using airspeeds of 80 to 110 KIAS. Again, 90 KIAS was determined to be the "best" airspeed to maintain. This simplified the instrument approach procedures by using just one airspeed throughout the entire pattern. It was determined, however, that the helicopter could be easily flown on final (that is, straight ahead descent) at airspeeds up to 110 KIAS. This is a cogent point, since helicopter airspeeds are not normally compatible with other fixed wing aircraft in the pattern and the higher airspeed could be readily used to reduce possible congestion within a crowded terminal area airspace.

Radar flight following of the UH-1N (without transponder) was marginal and at times completely unsatisfactory. Flight tests in the Panama Canal Zone revealed that FAA approach control radar could not distinguish the UH-1N when flown in and around rain showers or cumuloform clouds. Radar coverage was at times lost as close as 4 miles from the ground radar facility. This became extremely disconcerting to the pilots and also the FAA air traffic controllers when operating in the vicinity of other aircraft. Installation of the AN/APX-72 transponder eliminated this problem completely. It was recommended in the tropical weather test report (reference 2), that the AN/APX-72 transponder be installed in all UH-1N helicopters.

● Missed Approach

The Flight Manual procedure of decreasing airspeed to 70 KIAS by a two-bar-width pitch adjustment was not acceptable. It required an unnecessarily large pitch change and, as discussed earlier, left the helicopter at a relatively unstable airspeed. The essence of good (safe) instrument flying is to make positive but small and smooth attitude changes. Upon execution of a missed approach, sufficient power should be applied to establish a +500 to +1,000 fpm rate of climb and gradually attain an airspeed of 80 KIAS.

● Single-Engine Operation

Single-engine operation did not present a problem in the instrument flight procedures evaluation, however, under certain high gross weight/ high density altitude situations, insufficient power would be available to maintain altitude and/or desired airspeed. In this event whatever stabilized airspeed and altitude combination results should be accepted. The airspeed should not be allowed to decrease below 55 KIAS until landing is assured, since this would result in operating the aircraft "behind the power curve."

● Instrument Flight Procedures Evaluation Summary

In summary, the UH-1N was less unstable and therefore more comfortable to fly in actual weather conditions than previous models of the UH-1 helicopter. This improved stability, combined with an adequate display of basic flight instruments and navigational aids (figure 1), allows a pilot to fly safely in actual instrument weather conditions. However, because of the increased workload, basic instability, and vertigo inducing vibrations associated with all helicopters, two pilots are recommended for IFR flights.

Recommended changes to the Flight Manual made in the preceding paragraphs are included in the proposed rewrite of Section IX (reference 1) as contained in the Conclusions and Recommendations section of this report. (R 2)

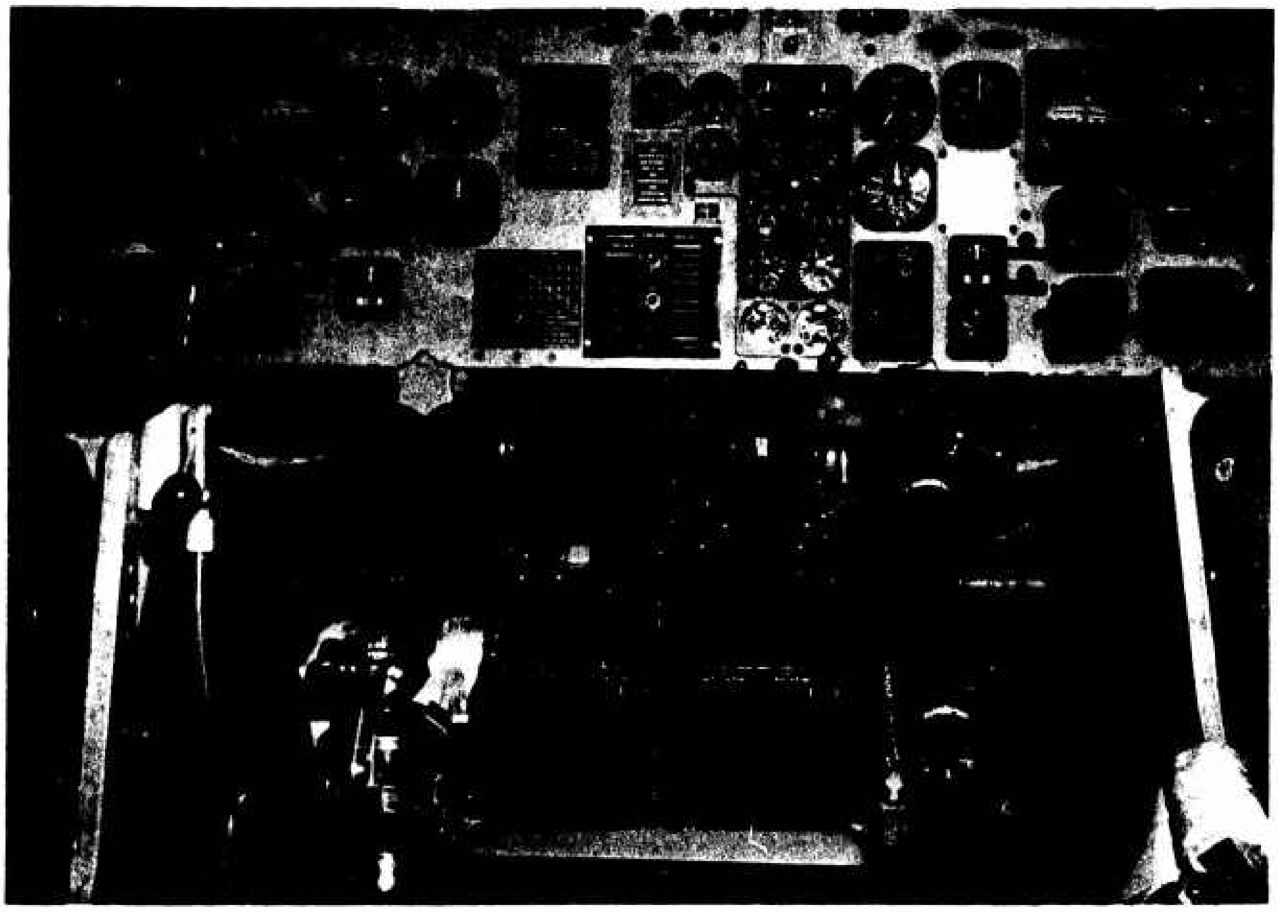


Figure 1 UH-1N Instrument Panels

■ FLIGHT OPERATIONS IN RAIN

As stated in the Flight Manual, rain had no noticeable effect on handling qualities or performance characteristics of the helicopter. The Flight Manual discussion of this subject was adequate.

For an analysis of flight test operations conducted in the rain see reference 2.

■ FLIGHT OPERATIONS IN TURBULENT AIR

Numerous flights were made in light to moderate turbulence. In every case, positive aircraft control could be maintained. The UH-1N was noticeably less unstable in turbulent air than the earlier model UH-1F helicopter. An airspeed of 80 KIAS was the most comfortable penetration airspeed, although this could be increased depending on the severity of the turbulence being encountered. The Flight Manual discussion of this subject was adequate.

■ NIGHT FLYING

Night flying presents some of the same problems as instrument flying, plus additional problems introduced by illumination of the instruments and cockpit, and exterior reflections. Two sorties were therefore flown at night to evaluate these potential problem areas.

No operational or flight procedure problems were encountered. The Flight Manual discussion of this subject was adequate.

On both sorties, searchlight operation was somewhat degraded. In one case the up limit switch was improperly set and the gear drive system failed when the searchlight contacted the fuselage. On the second flight, lateral movement of the search light proved to be sporadic - stopping prematurely and then continuing through a sweep as the pilot control switch was cycled OFF, then ON. RUMR's were submitted on these deficiencies.

As mentioned in the UH-1N AFPE (reference 5) activation of the secondary instrument lights gave the illusion of an illuminated engine fire handle, falsely indicating an engine fire. This was annoying, but was easily eliminated by turning the secondary instrument light switch off; these lights provided little if any useful assistance to the overall cockpit lighting.

■ ICING TEST

● General

Icing tests were conducted on the UH-1N at Malmstrom AFB (MAFB), Montana, from 1 through 7 February 1971, to determine the capabilities of UH-1N ice protection systems and overall aircraft adequacy in an icing environment. The program consisted of two phases - artificial and natural icing conditions. The artificial icing tests were conducted to determine the engine air particle separator (EAPS) system adequacy, heater-defroster system capabilities, and qualitative aircraft handling characteristics in trace through moderate icing conditions. Natural icing tests were conducted to qualify findings of the artificial icing tests.

● Ice Protection Subsystems

Ice Detector.

The UH-1N ice detector system consisted of an ice detector, ICING warning light, and heater. Power was supplied to the system from the 28-volt dc essential bus through the ICE DET circuit breaker. The ice detector warning light was designed to illuminate when ice accumulated on the probe located on the aircraft nose. When ice accumulated on the probe, the probe heater was activated for a period of five seconds which melted the ice.

Cabin Heat - Windshield Defrost.

The cabin heating-defrosting system used bleed air from the engines compressors as a heat source. It provided air to outlets on both door posts, both sides of the pedestal, the lower forward window areas, and to nozzles at both windshields, as selected by the pilots. These windshield nozzles were the only means provided to remove ice or frost from the windshields.

The test aircraft was configured with a winterization heater kit which provided better cabin heating and windshield defrosting capabilities. The winterization kit consisted of a larger mixing valve, a larger noise suppressor section, larger ambient air supply valve, and an additional 1 1/4-inch bleed air line installed between the bleed air port and the mixing valve.

The heating system was designed to maintain +40 degrees F mean cabin temperature with an outside air temperature of -65 degrees F within 30 minutes of start. Flow rate of bleed air required to provide the above temperature was 12 pounds per minute at a temperature of 450 degrees F (reference 6, para 3.23.11).

Pitot-Static System.

The pitot-static system consisted of an electrically heated pitot-static tube, static lines, static manifold, pitot lines and necessary piping to connect altimeters, vertical speed and airspeed indicators.

Aircraft Modification - De-Icing System.

The UH-1N windshield defrosting system was inadequate for ice removal as shown by results of the UH-1F icing test program (reference 7). Consequently, a de-icing system was installed to give the pilot visibility during icing tests. The system consisted of a 2-gallon tank (containing alcohol), an electric pump and flexible plastic hose (figures 2 and 3). The de-icing system received power from the aircraft 28-volt dc essential bus. When the system was activated, alcohol was pumped through plastic hose to the windshield wiper and onto the windshield.

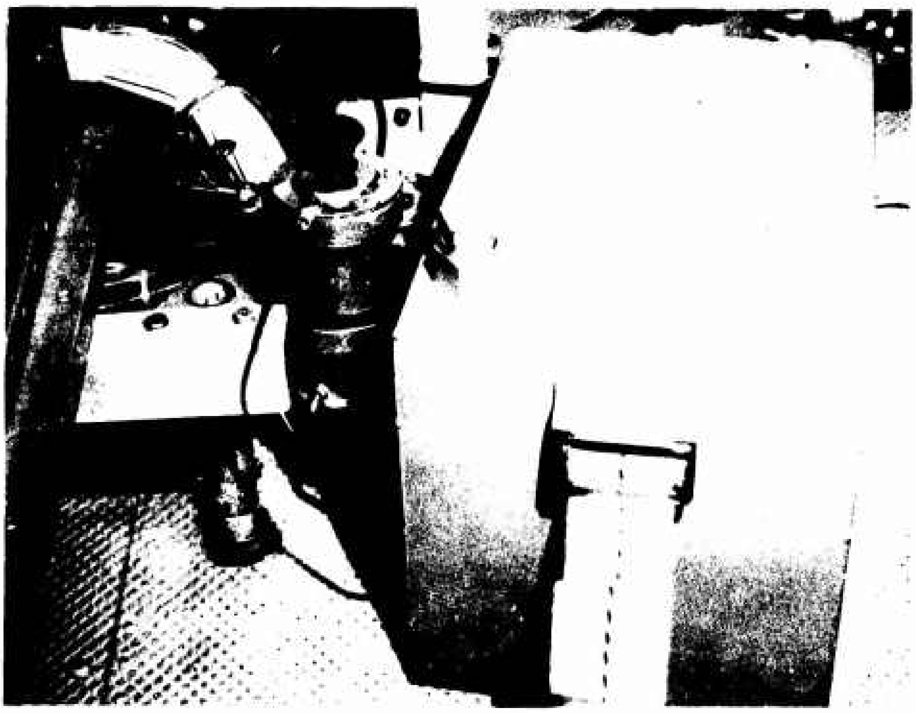


Figure 2 Class II Modification – De-Icing Pump and Alcohol Tank

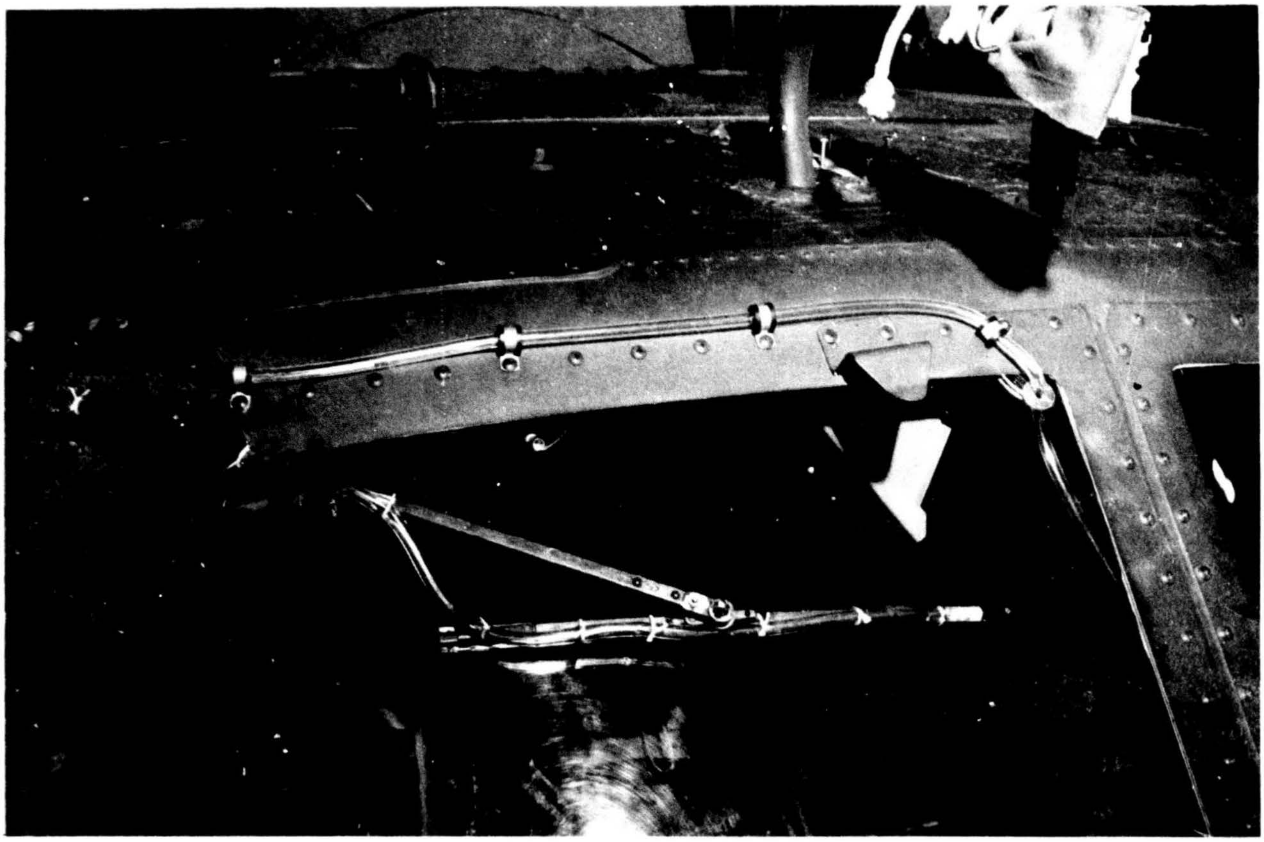


Figure 3 Class II Modification – Plastic Hose Attached to Wiper

● Test Methods

Artificial Icing.

The UH-1N test helicopter, the chase helicopter (UH-1F), and C-130 spray tanker rendezvoused over a predetermined area 18 miles north of MAFB, Montana (figure 4). Testing was conducted between 5,500 feet and 9,500 feet pressure altitude with freezing temperatures at the surface. Trace, light, and moderate conditions of clear and rime icing were evaluated (appendix III). The UH-1N was iced enroute to MAFB, over barren, sparsely populated terrain. After being iced, the UH-1N landed at MAFB to have photographs taken, ice accretion evaluated, and ice removed. Table IV lists test points. The test helicopter then rendezvoused with the C-130 to continue testing. For all test points, the UH-1N weighed approximately 8,200 pounds.

Natural Icing.

The UH-1N helicopter crew searched for natural icing conditions when and where possible. Three sorties were flown in trace through light icing conditions with clear and rime ice evident. Approximately 2.3 hours were flown in the conditions. No estimation of ice accumulation thickness on the airframe was possible due to poor visibility. The specific ambient temperatures for the sorties were: (a) -6 degrees C clear ice, (b) -5 degrees C clear ice, and (c) -13 degrees C rime ice.

Figure 4 Rendezvous of C-130 Water Spray Aircraft and UH-1N

Airframe (Artificial Icing).

Ice accumulation thickness on the synchronized elevators (figure 5) and tail rotor section was minimal (1/8-inch maximum) for all icing conditions (trace, light, moderate) tested. The tail rotor section accumulated about one-half as much ice as the nose and rotor hub areas for all test points. The helicopter aft section accrued less ice due to engine exhaust venting. Ice accrued up to 1/4-inch thick on the nose, windshield, rotor hub (figures 6 and 7) and engine inlet lips (figure 8) during test points 7 and 8 (table IV). No structural damage occurred during any of the icing tests conducted.

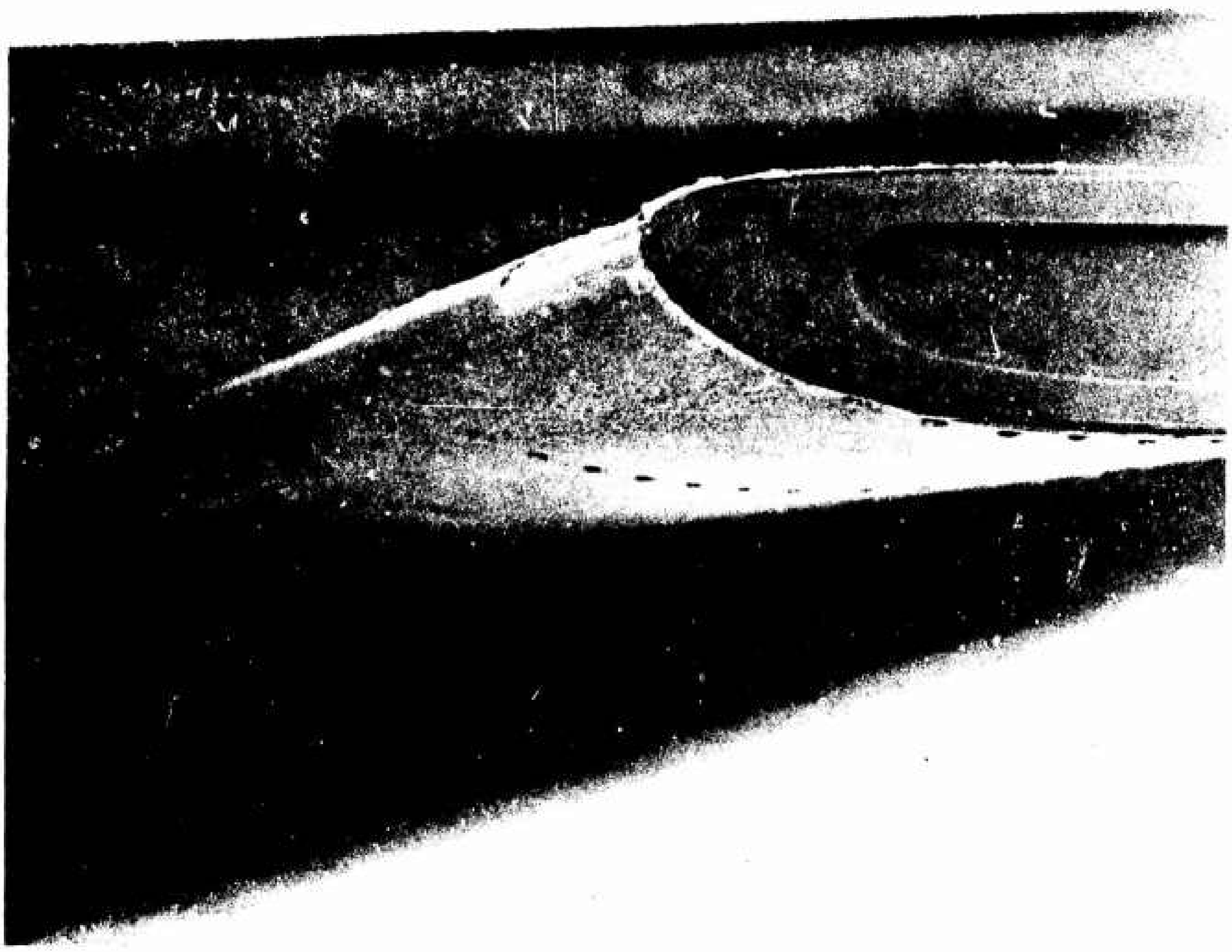


Figure 5 Clear Ice (1/8-inch Thick) on Synchronized Elevator (Test Point 8)

Figure 6   Clear Ice on UH-1N Nose and Windshield (Test Point 8)

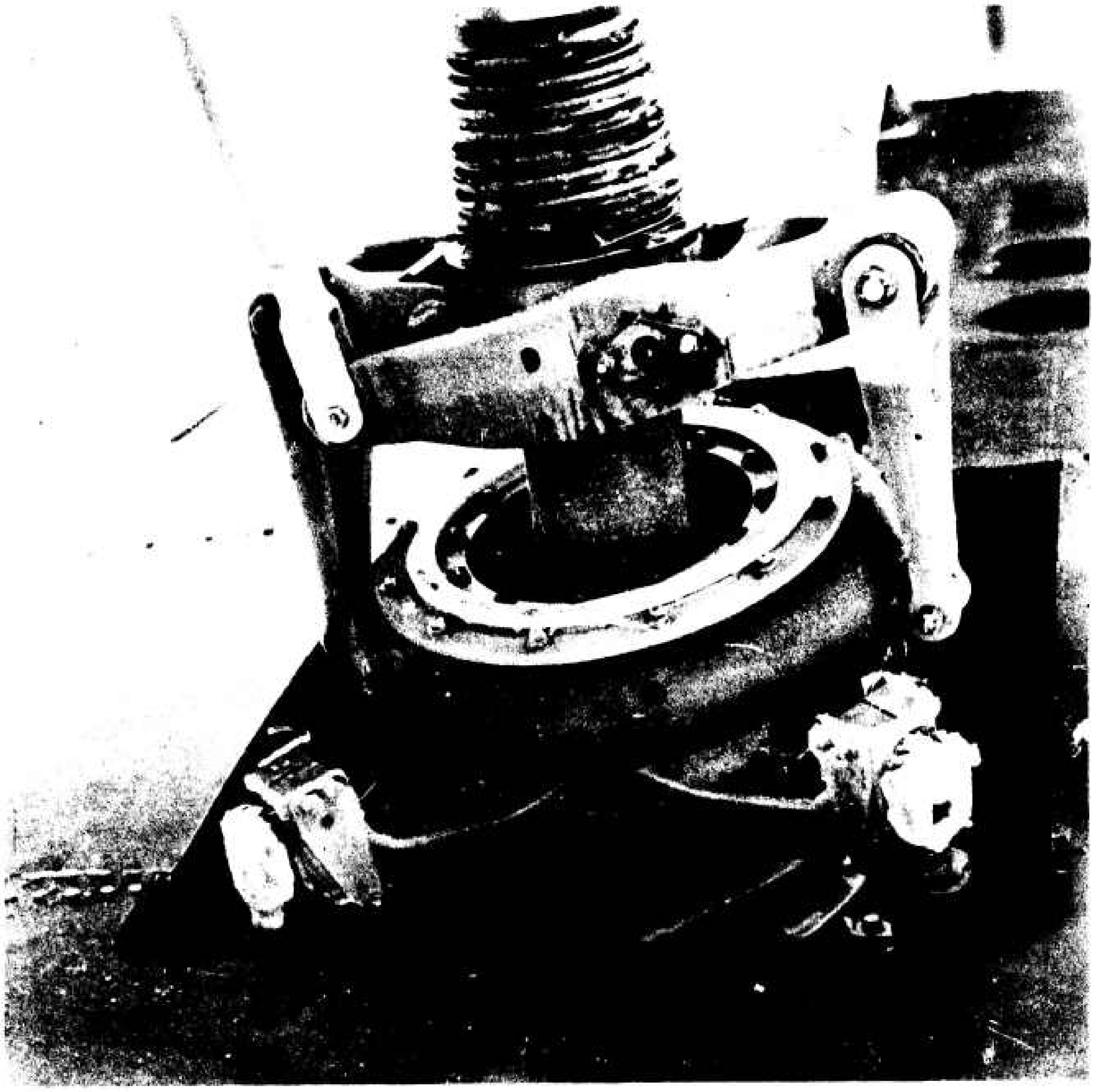


Figure 7 Clear Ice on Rotor Hub (Test Point 7)

Figure 8 Rime Ice on Engine Inlet Lip (Test Point 6)

Rotor Blades (Artificial Icing).

The rotor blades shed ice symmetrically (figure 9) with no structural damage inflicted on the airframe due to shedding ice. During clear icing (test point 7), the rotor blade ice was 3/8-inch thick on leading edge and shed symmetrically to within 6 feet of the rotor hub. Shedding occurred sporadically throughout each icing test point. The rotor blades shed ice symmetrically during all testing. No structural damage was evident to the blades during the test program.

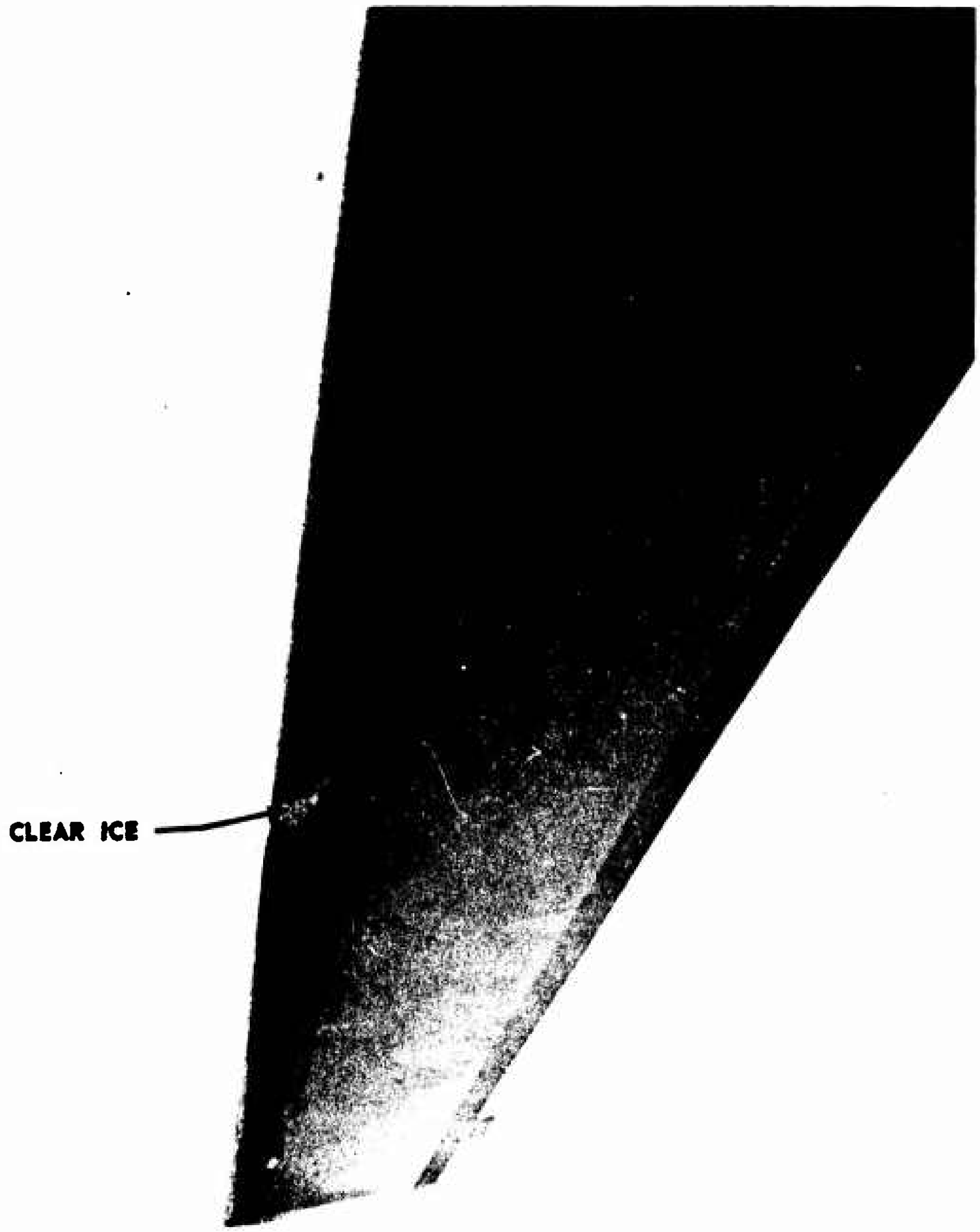


Figure 9 Clear Ice – Rotor Blade (Test Point 8)

Engine Air Particle Separator System (Artificial Icing).

The EAPS functioned adequately during all tests. No engine damage due to ice ingestion occurred.

Inside the inlet duct a slab of ice approximately 1/16 to 3/16-inch thick accumulated for most of the test points (figure 10). The ice slab was about 1.5 feet downstream from the inlet lip and on the upper surface of the inlet.

Since testing was conducted with freezing temperatures at all altitudes, the ice that accumulated in the inlet did not break free and enter in the engine. If warmer ambient temperatures are encountered after encountering icing conditions there is a possibility of engine damage due to ice ingestion.

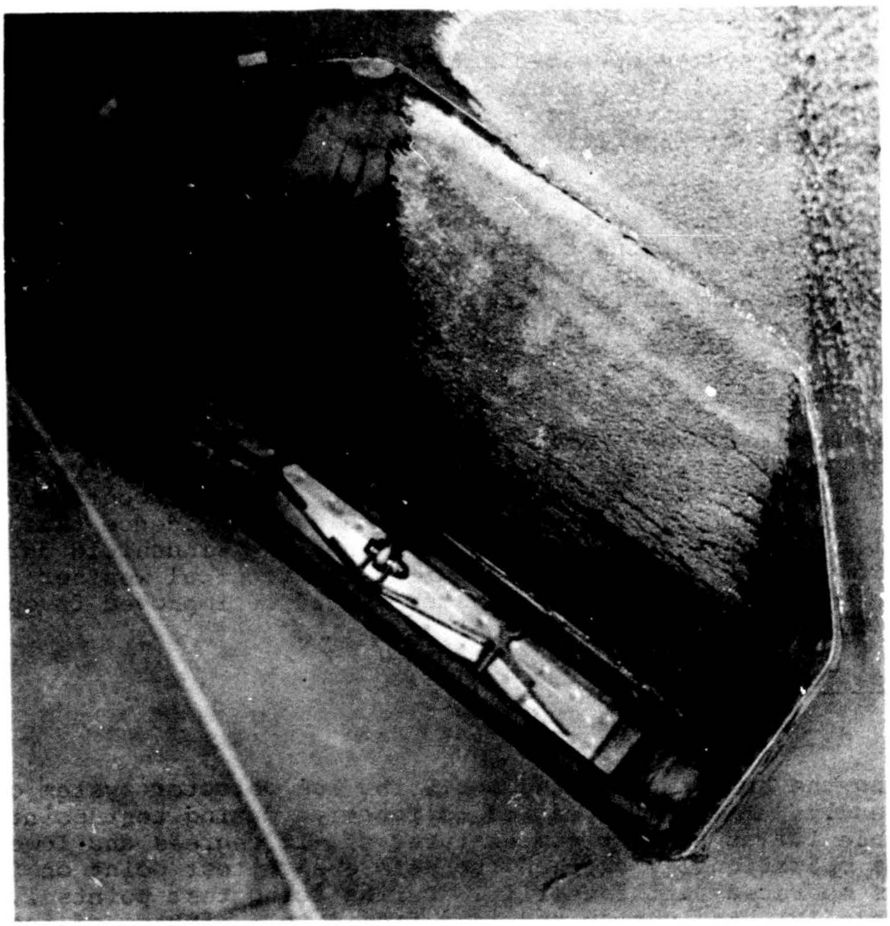


Figure 10 Ice Slab (Approximately 1/8-inch Thick) Inside Engine Duct (Test Point 8)

Cabin Heat-Windshield Defrost.

Artificial Icing

The heater-windshield defrost system operated satisfactorily in conjunction with the windshield wiper to keep the windshield free of ice for icing test points 1, 2, and 3 in table IV. The heater-windshield defrost system was configured with aft cabin outlets closed, cabin heaters off, and windshield defrost air at maximum temperature for each test point. The defrost system and windshield wiper were unable to keep the windshield from totally icing over (figure 11) after approximately 30 seconds of icing conditions, for light-moderate clear icing test points 7 and 8 in table IV. The system was also incapable of clearing the windshield of rime ice (figures 12, 13) after approximately 20 seconds in the rime icing conditions of test points 4, 5, and 6, table IV. The side and nose chin windows did remain sufficiently clear for use in landing the helicopter. The defrost windshield air blast was reflected off the windshield into the pilots faces during the entire test program, causing irritation. (R 4)

Natural Icing Test

The defrost system operated satisfactorily during the flights in trace and light clear icing conditions. However, the defrost system was again inadequate to remove ice from the windscreen, and in less than 30 seconds in the light rime icing condition encountered, the windscreen became opaque.

The heater-defrost system was not adequate to remove ice from the windshield during any icing condition (trace-light-moderate) at an outside air temperature (OAT) of -12 degrees C and colder. The system did function sufficiently during trace icing condition with an OAT of -5 degrees C to remove ice from the windshield.

Windshield Wiper (Artificial and Natural Icing).

The windshield wiper failed to start in LOW during all tests and operated intermittently when the control was turned to MEDIUM. The wiper functioned normally when the control was in HIGH. The control could not be set to any other position than HIGH with any confidence that the wiper would continue functioning. Wipers scratched the windshield during this test program as previously noticed during the tropical weather tests (reference 2). Windshield wiper system should be improved to operate reliably in all speed ranges. (R 6)

Ice Detector.

Artificial Icing Test

During the artificial icing tests the ice detector system operated intermittently. The system failed to function during test points 4, 5, and 6 (table IV) at ambient temperatures of -12 degrees and lower. The system was operationally checked out before each test point on the ground, and always operated satisfactorily. During icing test points 1, 2, 3, 7 and 8 (table IV), the system required from 1 to 3 minutes of ice buildup in trace, light, and moderate icing conditions before the ICING warning light illuminated.

Figure 11 Clear Trace Ice on Windshield (Test Point 1)

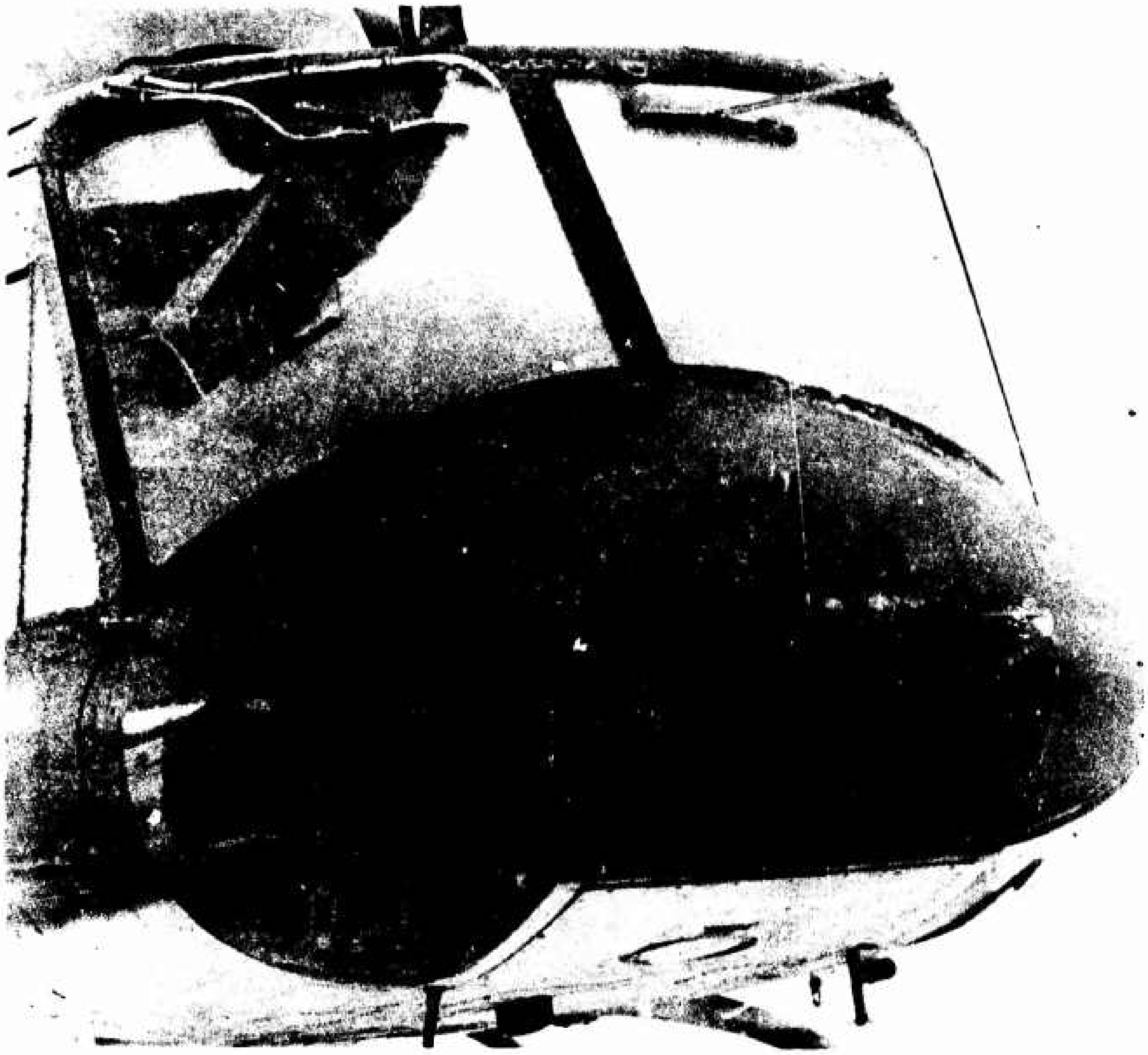


Figure 12 Rime Light Ice on Windshield (Test Point 5)

Natural Icing Test

The ICING warning lamp illuminated about 1 minute after encountering clear icing conditions at -5 degrees C ambient temperature. The warning lamp failed entirely to illuminate during flight in rime icing conditions (-13 degrees ambient temperature). The flight time in rime ice conditions was 35 minutes.

The ice detector system was unreliable and is unacceptable. This system should be corrected to function properly in all icing conditions. (R 5)

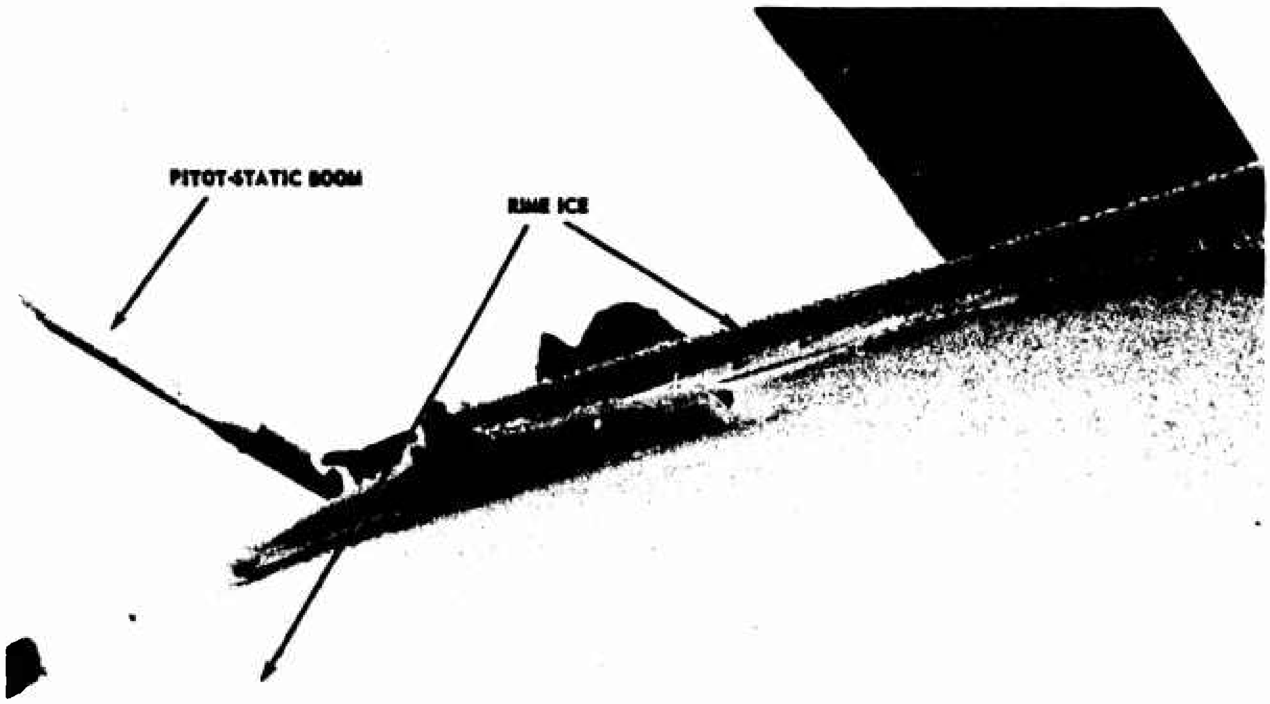


Figure 13 Rime Ice on Windshield/Wiper (Test Point 5)

Icing Flight Operational Analyses.

The UH-1N helicopter withstood all icing conditions tested with no mechanical defects or gross degradation of handling qualities noted. Ice accumulations of up to 3/8-inch were gathered on windshields, exposed flight control rod ends near rotor hub swash plate, engine inlet lip, and UHF/VHF antenna. The engine exhaust seemed to keep the synchronized elevators and tail rotor relatively clear of ice although accumulations of up to 1/8-inch were noted for the more severe icing test points. Under rime ice testing conditions, ice built up to within 5 feet of the main rotor tip - shedding symmetrically from both blades at that point. Under clear icing test conditions, ice shed symmetrically to within 6 feet of the main rotor hub assembly. Aircraft control/handling qualities were generally good (Cooper-Harper rating scale of 2, appendix II) throughout the test program; the only change occurred at test points 4, 5, and 6 (rime icing) when the overall helicopter vibration level increased slightly. There was also a significant increase in power required to maintain position behind the tanker as more and more ice was accumulated for these test points. No degradation of installed avionics operation was noted during icing conditions.

Four problem areas were identified during this test program:

1. The windshield wiper frequently stuck to the windshield. The wiper speed selector knob then had to be moved to HIGH position momentarily in order to free the wiper, thus increasing pilot workload.

2. Even with the UH-1N winterization kit installed, full defrost at maximum temperature when used in conjunction with the windshield wipers, was not enough to keep the windshield clear at OAT's of -13 degrees C and colder (rime icing regime). The consequence of not being able to see out the front windshield was threefold:

   a. VFR flight could not be maintained

   b. Terrain avoidance could not be assured if operating below minimum obstruction clearance altitude.

   c. A rapid descent to landing or autorotation could not be safely accomplished.

3. The engine inlet duct accumulated ice (approximately 80 square inches) during test points 2 through 8. Consequently, the possibility exists that this ice may have an effect on engine performance, that is,

   a. Engine airflow pattern

   b. Engine damage due to ice ingestion.

4. The ice detector system was unreliable and is unacceptable as configured.

Based on the preceding discussion, the UH-1N helicopter should be restricted from flight in icing conditions greater than clear trace; that is, the UH-1N should not be flown in areas of known icing conditions when the OAT is colder than -5 degrees C. (R 3)

Table IV

UH-1N ICING TEST SUMMARY

Test Point	OAT (deg C)	Airspeed (KIAS)	Liquid Water Content (gm/m^3)	Distance Behind Tanker (ft)	Time in Cloud (min)	Remarks
1	-7	105	0.1	600	4	Clear ice accumulation 1/16-inch thick. Trace ice on engine inlet, windscreen, rotor blades and rotor hub. (Trace icing condition)
2	-7	105	0.25	400	4	Clear ice accumulation - 1/32-1/16-inch thick on rotor blades, rotor hub and engine inlet. (Light icing conditions)
3	-7	105	0.4	300	3.5	Clear ice accumulation - 3/16-inch thick on engine inlet, windscreen and rotor hub. (Light icing condition)
4	-15	105	0.1	600	3	Rime ice accumulation - 1/8-inch thick on windscreen and aircraft nose. One-fourth inch ice on engine intakes, 1/8 inch ice formation inside engine inlet and on rotor blades. (Trace icing condition)
5	-16	105	0.25	400	3	Rime ice accumulation - 1/4-inch thick over all aircraft. Ice formation inside inlet duct. (Light icing condition)
6	-15	105	0.5	600	3	Rime ice accumulation - 1/4-inch thick on engine inlet, windscreen, rotor hub and rotors. Ice formation (1/4-inch thick) inside engine inlets. (Moderate icing condition)
7	-5	105	0.45	600	3	Clear ice accumulation - Approx 1/4-inch ice on all flat plate areas. Slight vibrations evident due to ice buildup. (Light, moderate icing conditions)
8	-5	105	0.55	600	3.5	Clear ice accumulation - 3/8-inch thick ice buildup on windscreen, rotors, rotor hub, and engine inlets. Aircraft vibration slight.

NOTE: 1. Pressure altitude operating regime was 5,500 - 9,500 feet.

2. Aircraft gross weight for test points was approximately 8,200 pounds.

CONCLUSIONS AND RECOMMENDATIONS

■ INSTRUMENT FLIGHT

Operational techniques and procedures were established for the UH-1N flight in IFR weather flight conditions and were recommended for inclusion in Section IX of the Flight Manual T.O. 1H-1(U)N-1. Safe flight in IFR weather is possible, but two pilots were recommended as minimum crew due to the pilot workload.

An acceptable altimeter bleed rate and a specific altitude to which to run a pitot static system tester had not been provided.

1. Paragraphs 9-33 and 9-34 of T.O. 1H-1(U)N-2-1 should be expanded to more clearly define the conduct of a pitot-static system leak check (page 3).

The instrument flight procedures evaluation revealed that a number of IFR techniques described in Section IX of the Flight Manual were incomplete and/or not optimum from a pilot workload standpoint.

2. The entire discussion of "Instrument Flight" as contained in the Flight Manual should be changed to read as follows: (page 7)

INSTRUMENT FLIGHT

INTRODUCTION

The helicopter has been provided with the necessary instruments and navigation radio equipment to accomplish missions from prepared or unprepared take-off or landing areas, under instrument operations including trace icing conditions, day or night. Instrument flights should be carefully planned, keeping in mind that icing conditions, turbulent air and thunderstorms will greatly affect the flight. Except for some repetition which is necessary for continuity of thought, the instrument flight procedures contain only the procedures that differ, or are in addition to normal procedures covered in other sections.

NOTE

Two pilots are recommended for planned instrument flight operations.

INSTRUMENT FLIGHT PROCEDURES

The hydraulic boost control, force trim, stabilizer bar, and automatic fuel control governing features give this helicopter a reasonable degree of stability and acceptable handling/control characteristics for instrument flight. However, precision instrument flying still requires good proficiency in basic instrument flying techniques and procedures. Inflight fluctuations of the turn and slip indicator brought about by helicopter vibration levels and turbulent air dictate that much greater use be made of the attitude indicator than in other aircraft. Otherwise, this helicopter is adaptable to all phases of instrument flying by application of basic instrument techniques.

To lessen pilot fatigue during instrument cruise and steady state descent, full use should be made of the force trim to "trim out" opposing control forces. The fatigue factor will also be considerably reduced if the pilot controls the helicopter as smoothly as possible. Rapid movement of the controls will increase the pilot workload and induce spatial disorientation or vertigo very rapidly in actual IFR conditions.

WARNING

Instrument flying is not to be attempted without an operating attitude indicator.

All instrument flying is to be done with the N_f speed set at 97 to 100 percent rpm. This rpm setting will decrease the chance of encountering retreating blade stall in turbulent air.

PREFLIGHT AND GROUND CHECKS

Perform the normal preflight inspections as outlined in the normal operating instructions in Section II. Particular attention should be given to proper operation of flight instruments, navigation equipment, external and internal lighting, windshield wipers, and defrosters, pitot heat, generators, inverters, and ice detector.

INSTRUMENT TAKEOFF

The attitude indicator should be adjusted by setting the pitch and roll adjustment knobs at the zero trim dots to assure that correct attitude indications will be given. Set the attitude indicator one bar width above the artificial horizon. If visibility permits a normal hover, the takeoff should be made from this position using normal takeoff procedures described in Section II and referring to the flight instruments to provide a smooth transition from VFR to IFR flight. In addition to those conditions which normally require an instrument takeoff (that is, precipitation, low ceilings, and night operation) helicopter-induced restrictions to visibility, such as dust or snow blown by the rotor downwash, may require an instrument takeoff.

Align the helicopter with the desired takeoff heading and cross check the heading indicator. Smoothly increase collective pitch to obtain desired power for takeoff. As takeoff power is obtained and the helicopter clears the ground, smoothly change the pitch attitude to a 5-degree nose low indication and maintain a level bank attitude. Maintain this attitude and cross check the vertical velocity indicator and altimeter for positive climb indications. After accelerating to 80 KIAS adjust the helicopter attitude as necessary and reduce the collective pitch as required to maintain a rate of climb of between 500 and 1000 feet per minute and an airspeed of 80 KIAS.

WARNING

> The airspeed, vertical speed, and altimeter are unreliable below 30 KIAS because of rotor downwash effect on the pitot static system. During takeoff, do not rely on these instruments until airspeed indicator reads at least 35 KIAS.

INSTRUMENT CLIMB

This helicopter handles well in climbs and climbing turns at the recommended climb rate of 500 to 1000 feet per minute and 80 KIAS. No change should be made in the collective pitch setting unless the airspeed and vertical velocity vary more than ± 5 KIAS or ± 100 feet per minute. Turns should be made using the attitude indicator to obtain the recommended 18-degree bank which approximates a standard rate turn. Any pitch attitude corrections should not exceed one bar width. The angle of bank should not exceed 30 degrees.

WARNING

> Climbs at speeds less than 80 KIAS and rates of climb greater than 1000 fpm will make it more difficult to control the attitude of the helicopter.

If the attitude indicator malfunctions while flying on instruments, and a climb is required, rate of climb should be maintained at 500 fpm or less as the situation dictates.

INSTRUMENT CRUISING FLIGHT

Upon establishing the desired cruise speed (80 to 100 KIAS), the attitude indicator should be set for a nose level indication; thereafter, any pitch or bank corrections should be made using the attitude indicator. Pitch indications should not exceed one bar width. The recommended angle of bank for cruising turns is the angle which will provide a standard rate turn (about 18 degrees) and should not exceed 30 degrees.

NORMAL DESCENTS

Enroute descents to traffic altitude can be initiated and maintained without difficulty using the following procedures.

1) Before commencing the descent, check and reset the attitude indicator, if necessary, for a nose level indication with the helicopter in straight and level flight at the desired cruise airspeed.

2) To establish the descent, reduce the torque and set up a 500 to 1,000 feet per minute rate of descent: maintain the desired cruise airspeed and pitch attitude. During the descent, the miniature aircraft will remain on the artificial horizon.

3) The recommended angle of bank for descending turns is the angle which will provide a standard rate turn (about 18 degrees) and should not exceed 30 degrees.

AUTOROTATIVE DESCENTS

Steady-state autorotative descents are not difficult to perform using instruments. However, due to initial helicopter yawing tendencies and the high rate of descent, they are recommended for emergencies (complete engine failure, etc.) only. The following procedures should be used for establishing and conducting autorotations on instruments.

1) Immediately following engine failure, reduce collective pitch to maintain desired rotor rpm.

2) Maintain level cruise presentation on attitude indicator, adjusting ± one bar width as necessary to maintain airspeed of 70 to 90 KIAS.

After the autorotation has been established and the helicopter is under positive control, complete the ENGINE FAILURE DURING FLIGHT emergency procedure described in Section III. If possible, descents should be made straight ahead. However, if a turn must be made, limit the angle of bank to 30 degrees.

HOLDING

The Flight Manual discussion of this subject was adequate with but one change. The holding airspeed should be 80 KIAS instead of 90 KIAS.

APPROACHES

The Flight Manual discussion of this subject was adequate with but one change. The approach airspeed should be 80 KIAS instead of 90 KIAS.

MISSED APPROACH

To conduct a missed approach, apply sufficient power to establish a 500 to 1,000 feet per minute rate of climb while adjusting the aircraft pitch attitude to attain an airspeed of 80 KIAS. After these conditions have been established, follow the normal instrument climb procedures.

——— END OF FLIGHT MANUAL SUBSTITUTION ———

Rain had no noticeable effect on handling qualities or performance characteristics of the helicopter.

The UH-1N was noticeably more stable in turbulent air than the earlier model UH-1F helicopter. Positive aircraft control was maintained in light to moderate turbulence.

No operational or flight procedure problems were encountered during the night evaluation of the UH-1N helicopter.

ICING

Two major problem areas determined during the icing program were: a) the windshield defrost system; and b) the unheated engine inlet duct. The windshield defroster kept the windshield free of ice during trace icing conditions at OAT's of -5 degrees C or warmer. The defrost system was inadequate in ice removal from the windshield after 30 seconds in light and moderate icing conditions of -5 degrees C or colder. The system was totally incapable of windshield ice removal during trace, light, moderate icing conditions at OATS of -12 degrees C or colder. The windshield became opaque after 30 seconds in this icing condition. Defroster air blast (maximum flow) reflecting off the windshield back into the pilots' faces was undesirable. The ice buildup in the inlet duct could be dangerous to the engines if extended flight in icing conditions is necessary.

3. It is recommended that the UH-1N helicopter be restricted from flight in icing conditions greater than clear trace, that is, the UH-1N should not be flown in areas of known icing conditions when the OAT is colder than -5 degrees C (page 22).

4. Based on the preceding conclusions, recommend that the Flight Manual, Section IX, page 9-5, under ICE AND RAIN, section NOTE, be changed to read as follows:

NOTE

> The side and nose chin windows may be used to effect a landing when the windshield defrosters fail to keep the windshield clear of ice with maximum available defrost heat. The windshield defrosters will fail to keep the windshield clear of ice during all icing conditions at an outside air temperature of -12 degrees C or colder (page 18).

The ice detector system failed to operate during artificial icing tests at OAT's of -12 degrees or colder. The ice detector system operated intermittently during icing tests; it required approximately 1 to 3 minutes of ice accretion before the ICING warning light illuminated.

5. This system should be modified to function properly in all icing conditions (page 20).

The tail rotor section and synchronized elevator accrued less ice than the rotor hub and aircraft nose due to engine exhaust venting.

The windshield wiper system did not function properly in the LOW and MEDIUM positions. The system did operate satisfactorily in HIGH.

6. Windshield wiper system should be provided capability to operate in all speed ranges (page 18).

No degradation of installed avionics operation was noted during icing conditions.

Aircraft control/handling qualities were generally good (Cooper-Harper rating scale of 2) throughout the test program.

APPENDIX I
INSTALLED AVIONICS

VOR . . . AN/ARN-82

TACAN . . . AN/ARN-65

IFF . . . AN/APX-72

UHF/AM . . . AN/ARC-116

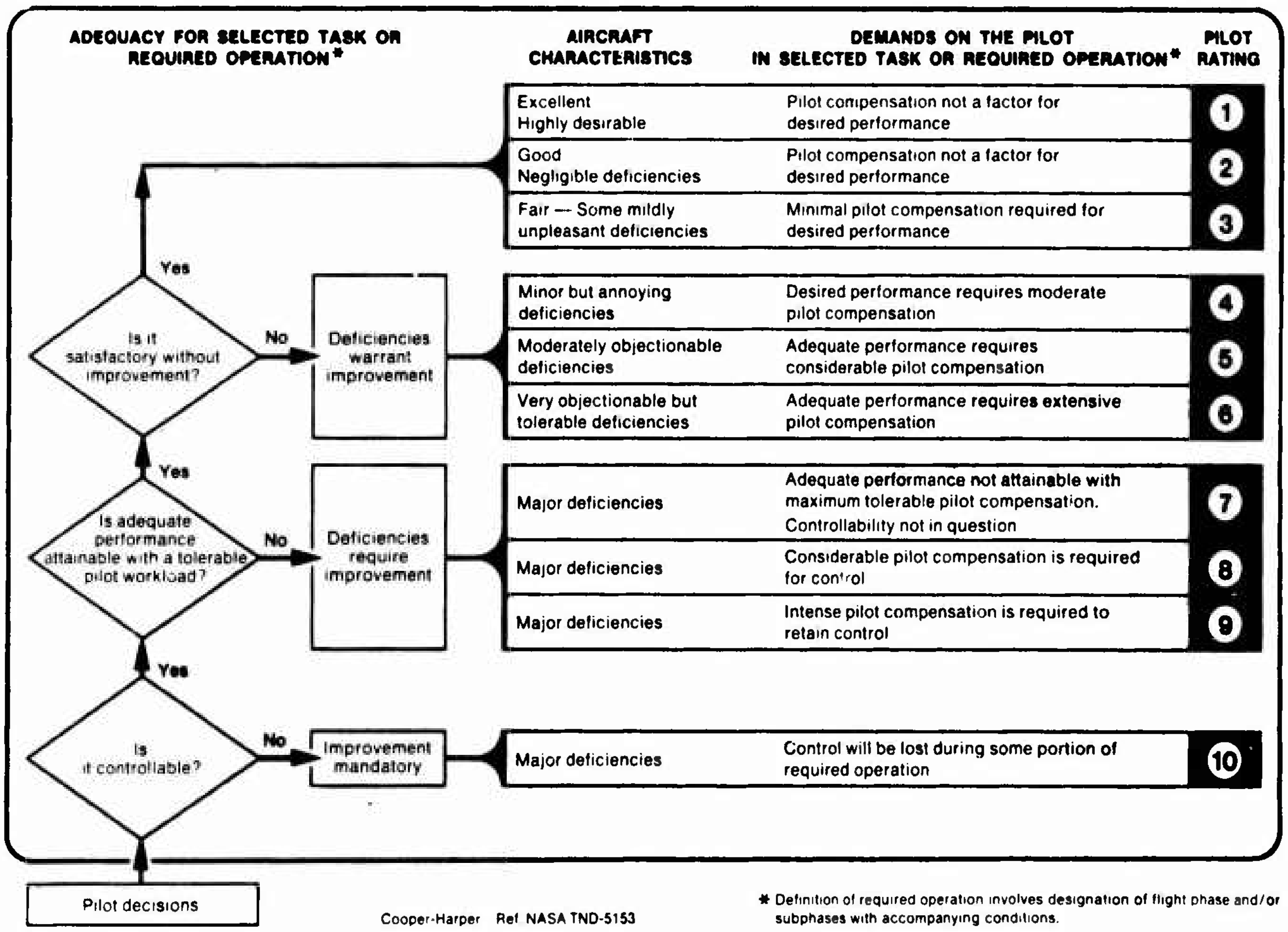
VHF/AM . . . AN/ARC-115

VHF/FM . . . AN/ARC-114

Gyromagnetic Compass . . . AN/ASN-43

UHF/DF . . . UHF-AM, AN/ARA-50

APPENDIX II
HANDLING QUALITIES RATING SCALE



Cooper-Harper Ref NASA TND-5153

* Definition of required operation involves designation of flight phase and/or subphases with accompanying conditions.

APPENDIX III
ICING DEFINITIONS

(Reference 8)

Condition	Liquid Water Content (grams/cubic meter)
Trace	0 < 0.1
Light	0.1 < 0.5
Moderate	0.5 < 1.0
Heavy	> 1.0

(mean drop size 25 microns)

TYPE OF ICE

Rime Ice - A brittle, opaque ice formed by instantaneous freezing of small super cooled droplets.

Clear Ice- A transparent hard ice, formed by slower freezing of larger super cooled droplets.

REFERENCES

1. Flight Manual USAF Series UH-1N Helicopter, T.O. 1H-1(U)N-1, 1 August 1970.

2. Ford, James A., and Angle, Theodore E., UH-1N Category II Tropical Weather Tests, FTC-TR-70-1, Air Force Flight Test Center, Edwards Air Force Base, California, February 1971.

3. Illustrated Parts Breakdown, USAF Models UH-1N Helicopter, T.O. 1H-1(U)N-4. 1 September 1970 (Chg 1, 15 September 1970).

4. Organizational Maintenance, USAF Models UH-1N Helicopter, T.O. 1H-1(U)N-2-1, 1 October 1970 (Chg 1, 15 November 1970).

5. Robert H. Springer, et al., Air Force Preliminary Evaluation of UH-1N Helicopter, FTC-TR-70-22, Air Force Flight Test Center, Edwards Air Force Base, California, August 1970.

6. Detailed Specification for Twin Engine Helicopter, Report No. 212-947-010, Bell Helicopter Company, 12-1-68.

7. Boudreaux, Elie J., Category II Adverse Weather Tests of the UH-1F Helicopter, ASD-TR-66-7, Aeronautical Systems Division, Wright-Patterson Air Force Base, Ohio, May 1966.

8. Forecasters Guide on Aircraft Icing, AWSM-105-39, 7 January 1969.

UNCLASSIFIED
Security Classification

DOCUMENT CONTROL DATA - R & D

(Security classification of title, body of abstract and indexing annotation must be entered when the overall report is classified)

1. ORIGINATING ACTIVITY (Corporate author)	2a. REPORT SECURITY CLASSIFICATION
Air Force Flight Test Center Edwards Air Force Base, California	UNCLASSIFIED
	2b. GROUP N/A

3. REPORT TITLE

UH-1N Instrument Flight, Turbulence, and Icing Tests

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

Final

5. AUTHOR(S) (First name, middle initial, last name)

Donald J. Dowden
Theodore E. Angle, Major, USAF

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
March 1971	32	8

8a. CONTRACT OR GRANT NO.	9a. ORIGINATOR'S REPORT NUMBER(S)
b. PROJECT NO.	FTC-TR-71-9
c. AFFTC Project Directive 69-49A	9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report)
d.	N/A

10. DISTRIBUTION STATEMENT

This document may be further distributed by any holder only with specific prior approval of ASD (SDQH), Wright-Patterson AFB, Ohio 45433.

11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY
N/A	6512th Test Group Edwards AFB, California

13. ABSTRACT

Operational techniques and procedures were established for the UH-1N flight in IFR weather flight conditions and were recommended for inclusion in Section IX of the Flight Manual T.O. 1H-1(U)N-1. Safe flight in IFR weather is possible, but two pilots were recommended as minimum crew due to the pilot workload. The UH-1N was flown in icing conditions with no mechanical defects or gross degradation of handling qualities noted. The windshield defrost system was inadequate to keep the windshield clear of ice and ice accumulated in the engine inlet duct throughout most of the icing tests conducted. Therefore, the UH-1N should be restricted from flight in icing conditions greater than clear trace; that is, in areas of icing conditions where the outside air temperature is colder than -5 degrees C.

DD FORM 1 NOV 65 1473

UNCLASSIFIED
Security Classification

UNCLASSIFIED

Security Classification

14. KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
UH-1N helicopter instrument flight turbulence icing						

UNCLASSIFIED

Security Classification

DEPARTMENT OF THE AIR FORCE

HEADQUARTERS AERONAUTICAL SYSTEMS DIVISION (AFSC)

WRIGHT-PATTERSON AIR FORCE BASE, OHIO 45433

REPLY TO ATTN OF: ASD/SDQH 11-142(Maj Rands/rb/52324/R&D 13-2-3/UH-1N)

3 DEC 1971

SUBJECT: ASD Addendum Report to FTC-TR-71-9

TO: Recipients of FTC-TR-71-9

This report is a part of and should remain attached to FTC-TR-71-9. Paragraph numbers below correspond to recommendations numbers in FTC-TR-71-9.

1. Concur - T.O. 1H-1(U)N-2-1 will be revised to more clearly define pitot-static system leak check procedures.

2. Non Concur - Existing text in the flight manual is the result of previous flight manual command review inputs. AFFTC recommended text is essentially the same as existing text, therefore this recommendation will be presented for consideration at the next flight manual command review. It should be noted that the information in the second "warning" on page 26 is not of sufficient importance to be considered a "warning" and is more appropriately a "note". In addition, the recommended holding and approach airspeed of 80 KIAS as shown on page 27 does not agree with the 90 KIAS recommended in the text on page 5.

3. Concur - Interim T.O. 1H-1(U)N-1S-23, dated 4 Oct 71 authorized IFR flight within the following criteria: "Intentional flight through known icing conditions with OAT colder than minus 5 degrees C is prohibited."

4. Concur with Intent - Interim T.O. 1H-1(U)N-1S-23, dated 4 Oct 71 added a note to the flight manual as follows: "The defrosters will not keep the windshield clear of ice in an icing condition with OAT colder than minus 12 degrees C." It should be noted that the defroster system was not designed nor intended to be a windshield de-icer.

5. Non Concur - The ice detector system was selected as the best available, however the present location of the detector probe may have caused the reported malfunctions. Due to the apparent limited value of the ice detector system and its reliability to date, consideration is being given to remove the entire system.

6. Non Concur - The wiper system was designed to operate in all speed ranges. The flight manual states that it may be necessary to set the control to "HIGH" to start the windshield wipers.

FOR THE COMMANDER

William D Eastman Jr

WILLIAM D. EASTMAN, JR., LT COL, USAF
Chief, Helicopter Programs Division
Directorate of Combat Systems
Deputy for Systems

Distribution List
UH-1N Flight Test Reports

	Rpt FTC-TR-70-22 AFPE (8/70)	Rpt FTC-TR-71-1 TWT (2/71)	Rpt FTC-TR-71-1 TWT (App. IV) (3/71)	Rpt FTC-TR-71-9 Inst Flt, Turb. Icing (3/71)	Rpt	Rpt	Rpt	Rpt
	No. of Cys	No. of Cys	No. of Cys	No. of Cys	No. of Cys	No. of Cys	No. of Cys	No. of Cys
HQ USAF WASHINGTON, D.C. 20330								
RDQ	1	1		1				
RDPN	1	1		1				
PRPL	1	1		1				
SAMI	1	1		1				
SMEMA	1	1		1				
SSSRA	1	1		1				
HQ AFSC ANDREWS AFB, MD. 20331								
DOV	1	1		1				
SDNS	12	12		12				
DLTA	1	1		1				
HQ ASD WRIGHT-PATTERSON AFB, OH. 45433								
SDQH	20	20	14	20				
SMPL	1	1		1				
XRHD	1	1		1				
HQ FTD WRIGHT-PATTERSON AFB, OH. 45433								
ENDI	1	1		1				
ENTE	1	1		1				
AFFDL WRIGHT-PATTERSON AFB, OHIO 45433								
FGC	1	1		1				
AFFTC EDWARDS AFB, CA 93523 (Internal)	67	67	30	67				
ADTC EGLIN AFB, FLA 32542								
ADBPS-12	1	1		1				
DLOZ		1		1				
DLYE		1		1				
HQ AFLC WRIGHT-PATTERSON AFB, OH. 45433								
MMACH	1	1		1				
MMPC	1	1		1				

Distribution List
UH-1N Flight Test Reports

	Rpt FTC-TR-70-22 AFPE (8/70) No. of Cys	Rpt FTC-TR-71-1 TWT (2/71) No. of Cys	Rpt FTC-TR-71-1 TWT (App. IV) (3/71) No. of Cys	Rpt FTC-TR-71-9 Inst Flt, Turb Icing (3/71) No. of Cys	Rpt No. of Cys	Rpt No. of Cys	Rpt No. of Cys	Rpt No. of Cys
DIR MAT MGMT (WRAMA) ROBINS AFB, GA 31093								
MMD-1	5	5	1	5				
MMEAP	1	1	1	1				
DIR MAT MGMT (SAAMA) KELLY AFB, TX 78241								
MMLO	5	5	1	5				
DIR MAT MGMT (OCAMA) TINKER AFB, OKLA 73145								
MMEAA	1	1	1	1				
HQ TAC LANGLEY AFB, VA 23365								
DRLS	1	1		1				
DMML	1	1		1				
DOSO	1	1		1				
USAF SOF EGLIN AFB, FLA 32542								
DM	1							
DRA	1							
DRF	1							
DPLPR	1							
DR		1		1				
1 SOW EGLIN AUX #9 AFB, FLA 32544								
DM	1	1		1				
317th SOS EGLIN AUX #9 AFB, FLA 32544	1	1		1				
834th FMS EGLIN AUX #9 AFB, FLA 32544	1	1		1				
HQ MAC SCOTT AFB, IL 62225								
DOQ	4	4		4				
HQ ARRS SCOTT AFB, ILL 62225								
ARXRD	1	1		1				

Distribution List
UH-1N Flight Test Reports

	Rpt FTC-TR-70-22 AFPE (8/70)	Rpt FTC-TR-71-1 TWT (2/71)	Rpt FTC-TR-71-1 TWT (App. IV) (3/71)	Rpt FTC-TR-71-9 Inst Flt, Turb, Icing (3/71)	Rpt	Rpt	Rpt	Rpt
	No. of Cys	No. of Cys	No. of Cys	No. of Cys	No. of Cys	No. of Cys	No. of Cys	No. of Cys
1550th ATTWG								
HILL AFB, UT 84401								
DO		3		3				
HQ ATC								
RANDOLPH AFB, TX 78148								
TMME	1	1		1				
TTAT-B	1	1		1				
HQ ATC								
SHEPPARD AFB, TX 76311								
TSOP-E	1	1		1				
TSOP-T	3	3		3				
3637 STURON (37ST/104)	1	1		1				
HQ COMD, USAF								
BOLLING AFB, WASHINGTON, D.C. 20332								
DOT	1	1		1				
DMM	1	1		1				
1 COMP Wg								
BOLLING AFB, WASHINGTON, D.C. 20332								
WDO	1	1		1				
DOHL	1	1		1				
HQ SAC								
OFFUTT AFB, NEV 68113								
OAI	1	1		1				
USAF ACADEMY, COLO 80840								
DFAN	1	1		1				
AIR UNIVERSITY								
MAXWELL AFB, ALA 36112								
AUL/LSE-6389	1	1		1				
DET 1 (CORONA HARVEST)								
MAXWELL AFB, ALA 36112								
ASI (ASD-IR)	1	1		1				
1002 IG GP								
NORTON AFB, CA 92409	1	1		1				
IGDSFR								
USAF SAM								
BROOKS AFB, TX 78235								
SMKEN	1	1		1				

Distribution List
UH-1N Flight Test Reports

	Rpt	Rpt	Rpt	Rpt	Rpt	Rpt	Rpt	Rpt
	FTC-TR-70-22 AFPE (8/70)	FTC-TR-71-1 TWT (2/71)	FTC-TR-71-1 TWT (App. IV) (3/71)	FTC-TR-71-9 Inst Flt, Turb, Icing (3/71)				
	No. of Cys	No. of Cys	No. of Cys	No. of Cys	No. of Cys	No. of Cys	No. of Cys	No. of Cys
CINCPACAF APO SAN FRANCISCO 96553 DORQ	1	1		1				
20th SOS APO SAN FRANCISCO 96326	1	1		1				
HQ USAFE APO NEW YORK 09633 DOL	1	1		1				
HQ 17AF APO NEW YORK 09012 DOOW	1	1		1				
7th SOS APO NEW YORK 09012 SOSO	2	2		2				
USAFSO APO NEW YORK 09825 OOT	1	1		1				
MME	1	1		1				
NAVAL AIR SYSTEMS COMMAND WASHINGTON, D.C. 20360 AIR-503-D	1	1		1				
AIR-5104C2	1	1		1				
AIR-5362		1		1				
OAP-31		1		1				
		1	1	1				
NAVAL AIR TEST CENTER FLIGHT TEST DIVISION PATUXENT RIVER, MD 20670 CT-14	1	1		1				
FT2312	2	2	1	2				
NAVAL AIR DEVELOPMENT CENTER JOHNSVILLE, WARMISTER, PA 18974 Commander (ADL)	1	1		1				
US ARMY BELL PLANT ACTIVITY P. O. BOX 1605 FT WORTH, TX 76101	2	2		2				

Distribution List
UH-1N Flight Test Reports

	Rpt FTC-TR-70-22 AFPE (H/70)	Rpt FTC-TR-71-1 TWT (2/71)	Rpt FTC-TR-71-1 TWT (App. IV) (3/71)	Rpt FTC-TR-71-9 Inst Flt, Turb Icing (3/71)	Rpt	Rpt	Rpt	Rpt
	No. of Cys	No. of Cys	No. of Cys	No. of Cys	No. of Cys	No. of Cys	No. of Cys	No. of Cys
US ARMY AVIA SYS COMD P. O. BOX 209 ST LOUIS, MO 63166 AMSAV-R-F	1	1		1				
COMMANDING OFFICER US ARMY AVIATION SYS TEST ACTIVITY EDWARDS AFB, CA 93523 SAVTE-P, REFERENCE & RESEARCH LIBRARY	20	20		20				
COMMANDING OFFICER US ARMY WEAPONS COMMAND ROCK ISLAND ARSENAL ROCK ISLAND, IL 61201 AMSWE-REW		1		1				
US ARMY AE & SW BOARD FT BRAGG, NC 28307 LIBRARIAN	1	1		1				
DCASO 141 LAURIER AVENUE OTTAWA 6, ONTARIO, CANADA	1	1		1				
1 CANADIAN FORCES LOGISTICS LIAISON UNIT WRIGHT-PATTERSON AFB, OH 45433 MCLRCA		10	2	10				
PASS TO:								
CHIEF OF DEFENSE STAFF CANADIAN FORCES HQ OTTAWA 4, ONTARIO, CANADA DASE2-2	8	(8)	(1)	(8)				
AEROSPACE ENG TEST ESTABLISHMENT CFB UPLANDS OTTAWA 10, ONTARIO, CANADA	2	(2)	(1)	(2)				

Distribution List
UH-1N Flight Test Reports

	Rpt FTC-TR-70-22 AFPE (8/70)	Rpt FTC-TR-71-1 TWT (2/71)	Rpt FTC-TR-71-1 TWT (App. IV) (3/71)	Rpt FTC-TR-71-9 Inst Flt, Turb Icing (3/71)	Rpt	Rpt	Rpt	Rpt
	No. of Cys	No. of Cys	No. of Cys	No. of Cys	No. of Cys	No. of Cys	No. of Cys	No. of Cys
BELL HELICOPTER COMPANY P. O. BOX 482 FT WORTH, TX 76101 UH-1N Program Mgr	2	2	1	2				
UNITED AIRCRAFT OF CANADA, LTD P. O. BOX 10 LANGUEIL, QUEBEC, CANADA T400-CP-400 Program Mgr	2	2	1	2				
FEDERAL AVIATION ADMINISTRATION 800 INDEPENDENCE AVE S.W. WASHINGTON DC 20590 Admin Standards Div. (MS-110)	2	2		2				
Flt Test Br. (FS-160)	2	2	1	2				
DEFENSE DOCUMENTATION CENTER CAMERON STATION ALEXANDRIA, VA 22314	20	10	5	10				
USDA-FOREST SERVICE EQPT DEVELOPMENT CENTER 444 E. BONITA AVE SAN DIMAS, CA 91773	1	1		1				
THE RAND CORP. (LIBRARY D) 1700 MAIN STREET SANTA MONICA, CA 90406 Dir., USAF Project RAND (via AF Liaison Office)	1	1		1				
SANDIA CORPORATION LIBRARY P. O. BOX 5800 ALBUQUERQUE, N.M. 87115	1	1		1				
TOTAL	239	234	60	234				

Distribution List
UH-1N Flight Test Reports

	Rpt	Rpt	Rpt	Rpt	Rpt	Rpt	Rpt	Rpt
	FTC-TR-70-22 APPE (8/70)	FTC-TR-71-1 TWT (2/71)	FTC-TR-71-1 TWT (App. IV) (3/71)	FTC-TR-71-9 Inst Flt, Turb Icing (3/71)				
	No. of Cys	No. of Cys	No. of Cys	No. of Cys	No. of Cys	No. of Cys	No. of Cys	No. of Cys
HQ USAF WASHINGTON, D.C. 20330								
RDQ	1	1		1				
RDPN	1	1		1				
PRPL	1	1		1				
SAMI	1	1		1				
SMEMA	1	1		1				
SSSRA	1	1		1				
HQ AFSC ANDREWS AFB, MD. 20331								
DOV	1	1		1				
SDNS	12	12		12				
DLTA	1	1		1				
HQ ASD WRIGHT-PATTERSON AFB, OH. 45433								
SDQH	20	20	14	20				
SMPL	1	1		1				
XRHD	1	1		1				
HQ FTD WRIGHT-PATTERSON AFB, OH. 45433								
ENDI	1	1		1				
ENTE	1	1		1				
AFFDL WRIGHT-PATTERSON AFB, OHIO 45433								
FGC	1	1		1				
AFFTC EDWARDS AFB, CA 93523								
(Internal)	67	67	30	67				
ADTC EGLIN AFB, FLA 32542								
ADBPS-12	1	1		1				
DLGZ		1		1				
DLYE		1		1				
HQ AFLC WRIGHT-PATTERSON AFB, OH. 45433								
MMACH	1	1		1				
MMPC	1	1		1				

Distribution List
UH-1N Flight Test Reports

	Rpt FTC-TR-70-22 AFPE (8/70) No. of Cys	Rpt FTC-TR-71-1 TWT (2/71) No. of Cys	Rpt FTC-TR-71-1 TWT (App. IV) (3/71) No. of Cys	Rpt FTC-TR-71-9 Inst Flt, Turb, Icing (3/71) No. of Cys	Rpt No. of Cys	Rpt No. of Cys	Rpt No. of Cys	Rpt No. of Cys
DIR MAT MGMT (WRAMA)								
ROBINS AFB, GA 31093								
MMD-1	5	5	1	5				
MMEAP	1	1	1	1				
DIR MAT MGMT (SAAMA)								
KELLY AFB, TX 78241								
MMLO	5	5	1	5				
DIR MAT MGMT (OCAMA)								
TINKER AFB, OKLA 73145								
MMEAA	1	1	1	1				
HQ TAC								
LANGLEY AFB, VA 23365								
DRLS	1	1		1				
DMML	1	1		1				
DOSO	1	1		1				
USAF SOF								
EGLIN AFB, FLA 32542								
DM	1							
DRA	1							
DRF	1							
DPLPR	1							
DR		1		1				
1 SOW								
EGLIN AUX #9 AFB, FLA 32544								
DM	1	1		1				
317th SOS								
EGLIN AUX #9 AFB, FLA 32544	1	1		1				
834th FMS								
EGLIN AUX #9 AFB, FLA 32544	1	1		1				
HQ MAC								
SCOTT AFB, IL 62225								
DOQ	4	4		4				
HQ ARRS								
SCOTT AFB, ILL 62225								
ARXRD	1	1		1				

Distribution List
UH-1N Flight Test Reports

	Rpt FTC-TR-70-22 AFPE (8/70)	Rpt FTC-TR-71-1 TWT (2/71)	Rpt FTC-TR-71-1 TWT (App. IV) (3/71)	Rpt FTC-TR-71-9 Inst Flt, Turb, Icing (3/71)	Rpt	Rpt	Rpt	Rpt
	No. of Cys	No. of Cys	No. of Cys	No. of Cys	No. of Cys	No. of Cys	No. of Cys	No. of Cys
1550th ATTWG HILL AFB, UT 84401 DO		3		3				
HQ ATC RANDOLPH AFB, TX 78148								
TMME	1	1		1				
TTAT-B	1	1		1				
HQ ATC SHEPPARD AFB, TX 76311								
TSOP-E	1	1		1				
TSOP-T	3	3		3				
3637 STURON (37ST/104)	1	1		1				
HQ COMD, USAF BOLLING AFB, WASHINGTON, D.C. 20332								
DOT	1	1		1				
DMM	1	1		1				
1 COMP Wg BOLLING AFB, WASHINGTON, D.C. 20332								
WDO	1	1		1				
DOHL	1	1		1				
HQ SAC OFFUTT AFB, NEV 68113 OAI	1	1		1				
USAF ACADEMY, COLO 80840 DFAN	1	1		1				
AIR UNIVERSITY MAXWELL AFB, ALA 36112 AUL/LSE-6389	1	1		1				
DET 1 (CORONA HARVEST) MAXWELL AFB, ALA 36112 ASI (ASD-IR)	1	1		1				
1002 IG GP NORTON AFB, CA 92409 IGDSFR	1	1		1				
USAF SAM BROOKS AFB, TX 78235 SMKEN	1	1		1				

Distribution List
UH-1N Flight Test Reports

	Rpt FTC-TR-70-22 AFPE (8/70) No. of Cys	Rpt FTC-TR-71-1 TWT (2/71) No. of Cys	Rpt FTC-TR-71-1 TWT (App. IV) (3/71) No. of Cys	Rpt FTC-TR-71-9 Inst Flt, Turb, Icing (3/71) No. of Cys	Rpt No. of Cys	Rpt No. of Cys	Rpt No. of Cys	Rpt No. of Cys
CINCPACAF APO SAN FRANCISCO 96553 DORQ	1	1		1				
20th SOS APO SAN FRANCISCO 96326	1	1		1				
HQ USAFE APO NEW YORK 09633 DOL	1	1		1				
HQ 17AF APO NEW YORK 09012 DOOW	1	1		1				
7th SOS APO NEW YORK 09012 SOSO	2	2		2				
USAFSO APO NEW YORK 09825 OOT	1	1		1				
MME	1	1		1				
NAVAL AIR SYSTEMS COMMAND WASHINGTON, D.C. 20360 AIR-503-D	1	1		1				
AIR-5104C2	1	1		1				
AIR-5362		1		1				
OAP-31		1		1				
		1	1	1				
NAVAL AIR TEST CENTER FLIGHT TEST DIVISION PATUXENT RIVER, MD 20670 CT-14	1	1		1				
FT2312	2	2	1	2				
NAVAL AIR DEVELOPMENT CENTER JOHNSVILLE, WARMISTER, PA 18974 Commander (ADL)	1	1		1				
US ARMY BELL PLANT ACTIVITY P. O. BOX 1605 FT WORTH, TX 76101	2	2		2				

Distribution List
UH-1N Flight Test Reports

	Rpt FTC-TR-70-22 AFPE (8/70)	Rpt FTC-TR-71-1 TWT (2/71)	Rpt FTC-TR-71-1 TWT (App. IV) (3/71)	Rpt FTC-TR-71-9 Inst Flt, Turb, Icing (3/71)	Rpt	Rpt	Rpt	Rpt
	No. of Cys	No. of Cys	No. of Cys	No. of Cys	No. of Cys	No. of Cys	No. of Cys	No. of Cys
US ARMY AVIA SYS COMD P. O. BOX 209 ST LOUIS, MO 63166 AMSAV-R-F	1	1		1				
COMMANDING OFFICER US ARMY AVIATION SYS TEST ACTIVITY EDWARDS AFB, CA 93523 SAVTE-P, REFERENCE & RESEARCH LIBRARY	20	20		20				
COMMANDING OFFICER US ARMY WEAPONS COMMAND ROCK ISLAND ARSENAL ROCK ISLAND, IL 61201 AMSWE-REW		1		1				
US ARMY AE & SW BOARD FT BRAGG, NC 28307 LIBRARIAN	1	1		1				
DCASO 141 LAURIER AVENUE OTTAWA 6, ONTARIO, CANADA	1	1		1				
1 CANADIAN FORCES LOGISTICS LIAISON UNIT WRIGHT-PATTERSON AFB, OH 45433 MCLRCA		10	2	10				
PASS TO:								
CHIEF OF DEFENSE STAFF CANADIAN FORCES HQ OTTAWA 4, ONTARIO, CANADA DASE2-2	8	(8)	(1)	(8)				
AEROSPACE ENG TEST ESTABLISHMENT CFB UPLANDS OTTAWA 10, ONTARIO, CANADA	2	(2)	(1)	(2)				

Distribution List
UH-1N Flight Test Reports

	Rpt FTC-TR-70-22 AFPE (8/70) No. of Cys	Rpt FTC-TR-71-1 TWT (2/71) No. of Cys	Rpt FTC-TR-71-1 TWT (App. IV) (3/71) No. of Cys	Rpt FTC-TR-71-9 Inst Flt, Turb Icing (3/71) No. of Cys	Rpt No. of Cys	Rpt No. of Cys	Rpt No. of Cys	Rpt No. of Cys
BELL HELICOPTER COMPANY P. O. BOX 482 FT WORTH, TX 76101 UH-1N Program Mgr	2	2	1	2				
UNITED AIRCRAFT OF CANADA, LTD P. O. BOX 10 LANGUEIL, QUEBEC, CANADA T400-CP-400 Program Mgr	2	2	1	2				
FEDERAL AVIATION ADMINISTRATION 800 INDEPENDENCE AVE S.W. WASHINGTON DC 20590 Admin Standards Div. (MS-110)	2	2		2				
Flt Test Br. (FS-160)	2	2	1	2				
DEFENSE DOCUMENTATION CENTER CAMERON STATION ALEXANDRIA, VA 22314	20	10	5	10				
USDA-FOREST SERVICE EQPT DEVELOPMENT CENTER 444 E. BONITA AVE SAN DIMAS, CA 91773	1	1		1				
THE RAND CORP. (LIBRARY D) 1700 MAIN STREET SANTA MONICA, CA 90406 Dir., USAF Project RAND (via AF Liaison Office)	1	1		1				
SANDIA CORPORATION LIBRARY P. O. BOX 5800 ALBUQUERQUE, N.M. 87115	1	1		1				
TOTAL	239	234	60	234				

DEPARTMENT OF THE AIR FORCE

HEADQUARTERS AERONAUTICAL SYSTEMS DIVISION (AFSC)

WRIGHT-PATTERSON AIR FORCE BASE, OHIO 45433

REPLY TO ATTN OF: ASD/SDQH 11-119 (Major Rands/52324/wln/R&D 13-2-3) 8 DEC 1971

SUBJECT: ASD Addendum to FTC-TR-71-1.

TO: Recipients of FTC-TR-71-1

This report is a part of and should remain attached to FTC-TR-71-1. ASD comments below correspond to recommendation numbers in FTC-TR-71-1.

1. Concur - Investigation of RUMR's will continue and appropriate corrective action will be taken.

2. Non Concur - Contractor advises that water contamination in the 90° gearbox will not occur with normal exposure to the elements either on the ground or in flight.

3. Concur - However, T.O. 1-1-1, paragraph 1-20 adequately covers this information.

4. Concur - ECP 616, "Provide Ram Air Cooling for the Center Console" and ECP 568, "Improve Standard Lightweight Avionics Equipment (SLAE) Radio Operations" have been approved and kits procured. ECP 616 will provide a method to lower the compartment temperature to be more compatible with equipment requirements and thus improve reliability. ECP 568 relocates cables and antennas to provide improved reception and range.

5. Concur - However, present UHF/VHF radios were selected because of their lightweight and small size. Similar equipment with pre-set channel capability was not available. Replacement/change is beyond the scope of the program at this time.

6. Concur - However, initial procurement and installation of a transponder was not within the scope of the program. Complete provisions for the AN/APX-72 are available on all UH-1N's. Sets must be obtained through requirements procedures.

FOR THE COMMANDER

William D Eastman Jr

WILLIAM D. EASTMAN, JR., LT COL, USAF
Chief, Helicopter Programs Division
Directorate of Combat Systems
Deputy for Systems